Claims

1. A method of dispensing a flowable material onto a workpiece comprising:

providing a dispensing apparatus comprising an orifice member having first and second surfaces and a bore therethrough between the surfaces, a pressurized chamber adjacent the orifice member first surface for flowable material, and a punch having a face movable through the orifice member bore;

providing a flowable material in the chamber;

positioning the punch outside the orifice member bore such that the punch face is spaced from the orifice member first surface;

flowing a desired amount of flowable material onto the punch face;

moving the punch and desired amount of flowable material on the punch face through the orifice member bore until the punch face extends beyond the orifice member second surface;

contacting the workpiece with the desired amount of flowable material while still on the punch face;

depositing the desired amount of flowable material onto the workpiece; and

retracting the punch until the punch face is substantially coplanar with the orifice member second surface.

2. The method of claim 1 wherein, after the punch face is substantially coplanar with the orifice member second surface, further including cleaning the punch face and coplanar orifice member second surface to remove any residual flowable material thereon.

3. The method of claim 1 wherein the chamber has larger diameter than the orifice member bore.

4. The method of claim 1 wherein the orifice member lower surface does not contact the workpiece.

5. The method of claim 1 wherein the punch creates a sliding seal fit inside the orifice member bore and wherein the step of retracting the punch until the punch face is substantially coplanar with the orifice member second surface simultaneously seals the bore and chamber.

6. The method of claim 1 wherein the orifice member bore diameter is less than 72 μm.

7. The method of claim 1 wherein the flowable material is deposited with a diameter less than 50μm.

8. The method of claim 1 wherein less than 50 picolitres of the flowable material is deposited on the workpiece.

9. The method of claim 1 wherein the flowable material is a conductive, adhesive paste and the workpiece is a ceramic greensheet.

10. The method of claim 1 further including continuously repeating the depositing of the desired amount of flowable material onto the workpiece a plurality of times.

11. The method of claim 1 further including repeating the depositing of the desired amount of flowable material onto a previously deposited amount of flowable material to create a desired height of flowable material on the workpiece.

12. The method of claim 1 wherein the flowable material is a conductive paste and the workpiece is a ceramic greensheet having a via opening therein, and including depositing of the desired amount of flowable conductive paste into the via opening.

13. The method of claim 1 wherein the flowable material is a conductive paste and the workpiece is a ceramic greensheet, and including repeatedly depositing desired amounts of flowable conductive paste adjacent previously deposited amounts of flowable material to create a line of conductive paste on the ceramic greensheet.

14. The method of claim 1 including continuously repeating the flowing of the flowable material onto the punch face and the depositing of the flowable material onto the workpiece, and further including simultaneously adjusting the spacing of the punch face from the orifice member first surface to adjust the desired amount of flowable material on the punch face.

15. The method of claim 1 including continuously repeating the flowing of the flowable material onto the punch face and the depositing of the flowable material onto the workpiece, and further including simultaneously adjusting the distance the punch face extends beyond the orifice member second surface to adjust the diameter of the desired amount of flowable material deposited onto the workpiece.

16. The method of claim 1 including continuously repeating the flowing of the flowable material onto the punch face and the depositing of the flowable material onto the workpiece, and further including simultaneously measuring size of the flowable material deposited onto the workpiece and using the size measurement to adjust the distance the punch face extends beyond the orifice member second surface and the size of the desired amount of flowable material deposited onto the workpiece.

17. The method of claim 1 further including pressurizing the flowable material in the chamber to flow the desired amount of flowable material onto the punch face, without forcing the flowable material out through the orifice member bore, when the punch is positioned outside the orifice member bore and the punch face is spaced from the orifice member first surface.

18. The method of claim 1 including, prior to extending the punch face beyond the orifice member second surface and depositing the desired amount of flowable material onto the workpiece, repeatedly moving the punch from a position outside the orifice member bore, where the punch face is spaced from the orifice member first surface, through the orifice member bore to a position where the punch face is substantially coplanar with the orifice member second surface.

19. The method of claim 1 further including measuring the distance of the workpiece to the orifice member second surface and, using the distance measurement, adjusting the distance the punch face extends beyond the orifice member second surface and the diameter of the desired amount of flowable material deposited onto the workpiece.

20. A method of dispensing a conductive paste onto a ceramic greensheet comprising:

providing a dispensing apparatus comprising an orifice member having first and second surfaces and a bore therethrough between the surfaces, a chamber adjacent the orifice member first surface for conductive paste, and a punch having a face movable through the orifice member bore;

providing conductive paste in the chamber;

positioning the punch outside the orifice member bore such that the punch face is spaced from the orifice member first surface;

depositing the desired amount of conductive paste onto the greensheet by flowing a desired amount of conductive paste onto the punch face, moving the punch and desired amount of conductive paste on the punch face through the orifice member bore until the punch face extends beyond the orifice member second surface, contacting the greensheet with the desired amount of conductive paste while still on the punch face, and transferring the desired amount of conductive paste onto the greensheet in the form of a dot;

depositing additional desired amounts of conductive paste onto the greensheet in the form of dots;

calibrating size of the dots of conductive paste applied onto the greensheet by measuring the size of the dots;

adjusting parameters for dispensing the conductive paste onto the greensheet based on measurements of the size of the dots; and

retracting the punch until the punch face is substantially coplanar with the orifice member second surface.

21. The method of claim 20 wherein, after the punch face is substantially coplanar with the orifice member second surface, further including cleaning the punch face and coplanar orifice member second surface to remove any residual flowable material thereon.

22. The method of claim 20 wherein calibrating size of the dots of conductive paste further includes determining rate of change of the size of the dots on the greensheet, determining average size of the dots on the greensheet, and determining difference in size between dots on the greensheet; and wherein adjusting parameters for dispensing the conductive paste onto the greensheet based on one or more of the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the greensheet.

23. The method of claim 22 further including assigning a calibration score based on the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the workpiece surface.

24. An apparatus for dispensing a flowable material onto a workpiece comprising:
an orifice member having first and second surfaces and a bore therethrough between the surfaces;
a chamber adjacent the orifice member first surface for flowable material;
a punch having a face movable through the orifice member bore;
a support for supporting a workpiece a desired distance from the orifice member second surface; and
a control system for operating the punch, the control system adapted to position the punch outside the orifice member bore such that the punch face is spaced from the orifice member first surface, flow a desired amount of flowable material onto the punch face, move the punch and desired amount of flowable material on the punch face through the orifice member bore until the punch face extends beyond the orifice member second surface, contact the workpiece with the desired amount of flowable material while still on the punch face, deposit the desired amount of flowable material onto the workpiece, and retract the punch until the punch face is substantially coplanar with the orifice member second surface.

25. The apparatus of claim 24 further including a sensor for measuring the size of the amount of flowable material deposited onto the workpiece, and a calibration system for calibrating size of dots of flowable material applied onto the workpiece by adjusting parameters for dispensing the flowable material onto the workpiece based on measurements of the size of the dots by the sensor.

26. The apparatus of claim 24 further including a sensor for measuring the size of the amount of flowable material deposited onto the workpiece, and wherein the control system is adapted to use the deposited flowable material size measurement to adjust the spacing of the punch face from the orifice member first surface to adjust the desired amount of flowable material on the punch face and the size of the desired amount of flowable material subsequently deposited onto the workpiece.

27. The apparatus of claim 24 further including a first sensor for measuring the distance of the workpiece to the orifice member second surface and a second sensor for measuring the size of the amount of flowable material deposited onto the workpiece, and wherein the control system is adapted to use the workpiece distance measurement and the deposited flowable material size measurement to adjust the distance the punch face extends beyond the orifice member second surface and the size of the desired amount of flowable material subsequently deposited onto the workpiece.

28. A method of calibrating size of flowable material dots applied onto a workpiece surface comprising:

dispensing flowable material in the form of separate, spaced-apart dots onto a workpiece surface;

measuring the size of the dots on the workpiece surface;

determining rate of change of the size of the dots on the workpiece surface;

determining average size of the dots on the workpiece surface;

determining difference in size between dots on the workpiece surface; and

adjusting parameters for dispensing the flowable material onto the workpiece surface based on one or more of the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the workpiece surface.

29. The method of claim 28 further including assigning a calibration score based on the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the workpiece surface.

30. An article of manufacture comprising a computer-usable medium having computer readable program code means embodied therein for calibrating size of flowable material dots applied onto a workpiece surface, the computer readable program code means in said article of manufacture comprising:

computer readable program code means for measuring the size of the dots on the workpiece surface;

computer readable program code means for determining rate of change of the size of the dots on the workpiece surface;

computer readable program code means for determining average size of the dots on the workpiece surface;

computer readable program code means for determining difference in size between dots on the workpiece surface; and

computer readable program code means for adjusting parameters for dispensing the flowable material onto the workpiece surface based on one or more of the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the workpiece surface.

31. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for calibrating size of flowable material dots applied onto a workpiece surface, said method steps comprising:

measuring the size of the dots on the workpiece surface;

determining rate of change of the size of the dots on the workpiece surface;

determining average size of the dots on the workpiece surface;

determining difference in size between dots on the workpiece surface; and

adjusting parameters for dispensing the flowable material onto the workpiece surface based on one or more of the determinations of rate of change of the size of the dots, average size of the dots and difference in size between smallest and largest dots on the workpiece surface.